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EXPERIMENT 34
HOOKE'S LAW

In 1676, Robert Hooke made an important discovery involving springs. He discovered that the distance a spring would stretch or compress was directly proportional to the force applied. This relationship can be written as

$$F = kx$$

The constant of proportionality which relates the applied force and the distance is the spring constant k. When the spring is stretched or compressed, energy is stored in the spring in the form of potential energy. The potential energy stored in a spring depends upon the spring constant and the distance the spring is stretched or compressed.

$$PE_s = \frac{1}{2}kx^2$$

A stiff spring has a large spring constant and a weak spring has a small spring constant.

OBJECTIVE

To graph the relationship between force and the distance the spring is stretched in order to determine the spring constant. To understand the relationship between the distance the spring is stretched and the potential energy stored in the spring.

EQUIPMENT

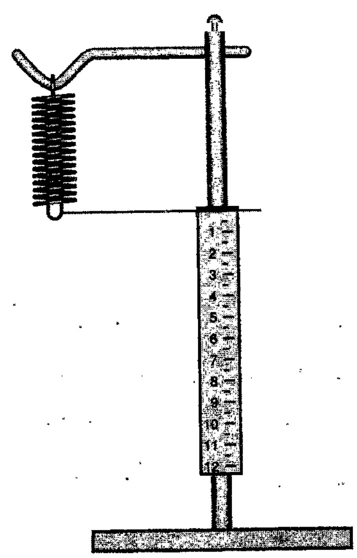
Hooke's law apparatus

hooked mass set

PROCEDURE

Measurement of stretch

1. Assemble Hooke's law apparatus as shown below.



2. With the spring unloaded, record the initial height of the bottom of the spring. Record all information in the following table.

3. Connect a small hooked mass to the bottom of the spring.

4. Allow the spring to stretch freely and record the final height of the bottom of the spring.

0.005

FORCE ON THE SPRING

Mass, g	Initial height, cm	Final height, cm	Force, N	Distance stretched, cm
5	36 cm	35.4	0.049	0.6
15	36 cm	34	0.147	2
25	36 cm	32.8	0.245	3.2
35	36 cm	31.1	0.343	4.9
45	36 cm	29.8	0.441	6.2

F = (0.6) K

5. Find the force due to the mass on the spring.

HINT Be sure to convert the mass to kilograms so the force will be in newtons.

6. Calculate the distance the spring stretched by subtracting the final height minus the initial height.

7. Repeat this procedure four more times, each time using a slightly larger mass.

Graphical analysis

8. Using the data from the table, plot a graph of the force versus the distance stretched.

9. Draw a straight line through the point (0, 0) that best fits the plotted data points.

10. The slope of the line is the spring constant. Find the spring constant k.

$\frac{0.25}{3.5}$

$k =$ 0.07 N/cm

7.35

1 cm

11. Using the calculated spring constant, calculate the potential energy for each distance stretched.

NOTE You must convert each distance stretched to meters before calculating the PE_s. You must also convert the spring constant to newtons per meter.

K=7.35

POTENTIAL ENERGY

Distance stretched, m	PE_s, J
0.006	1.32×10^{-4}
0.02	1.47×10^{-3}
0.032	3.76×10^{-3}
0.049	8.82×10^{-3}
0.062	0.014

12. Plot a graph of the potential energy of the spring versus the distance stretched.

13. Draw a curved line through the point (0, 0) that best fits the plotted data points.

Analysis

1. Is a linear model an appropriate representation for the force versus distance stretched graph? Why?

2. Why does the potential energy of the spring versus distance stretched curve increase rapidly as the distance stretched increases?

3. Could a rubber band have been used to replace the spring in the experiment? Give some reasons why or why not.

4. Define the elastic limit of a spring. How would you calculate the elastic limit of your spring?

5. Would a stiff spring or a weak spring have greater potential energy when compressed the same distance? Give a reason why.